US009580293B2

(12) **United States Patent**
Birtcher et al.

(10) **Patent No.: US 9,580,293 B2**
(45) **Date of Patent: Feb. 28, 2017**

(54) **DIPTUBE DESIGN FOR A HOST AMPOULE**

(71) Applicant: **AIR PRODUCTS AND CHEMICALS, INC.**, Allentown, PA (US)

(72) Inventors: **Charles Michael Birtcher**, Valley Center, CA (US); **Gildardo Vivanco**, San Diego, CA (US); **William Jon Sheehy**, Valley Center, CA (US)

(73) Assignee: **AIR PRODUCTS AND CHEMICALS, INC.**, Allentown, PA (US)

(21) Appl. No.: **14/744,133**

(22) Filed: **Jun. 19, 2015**

(65) **Prior Publication Data**

US 2015/0368087 A1 Dec. 24, 2015

Related U.S. Application Data

(60) Provisional application No. 62/016,367, filed on Jun. 24, 2014.

(51) **Int. Cl.**
B67D 7/02 (2010.01)

(52) **U.S. Cl.**
CPC ***B67D 7/0288*** (2013.01); *Y10T 29/49828* (2015.01)

(58) **Field of Classification Search**
CPC B67D 7/0288; Y10T 29/49828
USPC 222/464.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,371,822	A *	3/1968	Galloway	A23G 9/045	220/86.1
4,440,319	A	4/1984	Nitchman et al.		
4,531,656	A	7/1985	Nitchman et al.		
5,069,243	A	12/1991	Foreman		
5,199,603	A	4/1993	Prescott		
5,562,132	A *	10/1996	Siegele	B01J 4/00	137/209
5,663,503	A	9/1997	Dam et al.		
5,782,381	A	7/1998	Woodruff et al.		
5,988,456	A *	11/1999	Laible	B67D 7/0294	222/464.1
6,077,356	A	6/2000	Bouchard et al.		
7,124,913	B2	10/2006	Birtcher et al.		
2004/0262327	A1 *	12/2004	Birtcher	B67D 7/0272	222/64

FOREIGN PATENT DOCUMENTS

JP	H07024751	5/1995
KR	200427901	10/2006

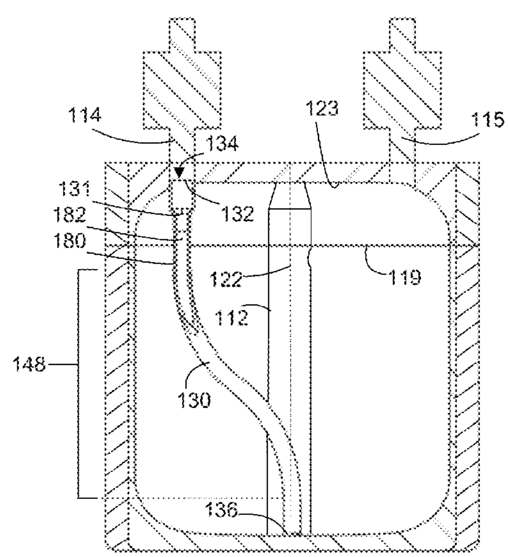
* cited by examiner

Primary Examiner — Donnell Long
(74) *Attorney, Agent, or Firm* — Lina Yang

(57) **ABSTRACT**

In one respect, the invention is an improved diptube design for a container for containing and dispensing a liquid chemical, the diptube generating a spring force when compressed that acts to maintain a bottom end of the diptube in contact with a bottom interior surface of the container and a notch located at a bottom edge of the bottom end of the diptube that creates a flow communication between the diptube and the interior volume of the base portion of the container. In another respect, the invention is a method of constructing a container having these limitations.

19 Claims, 5 Drawing Sheets



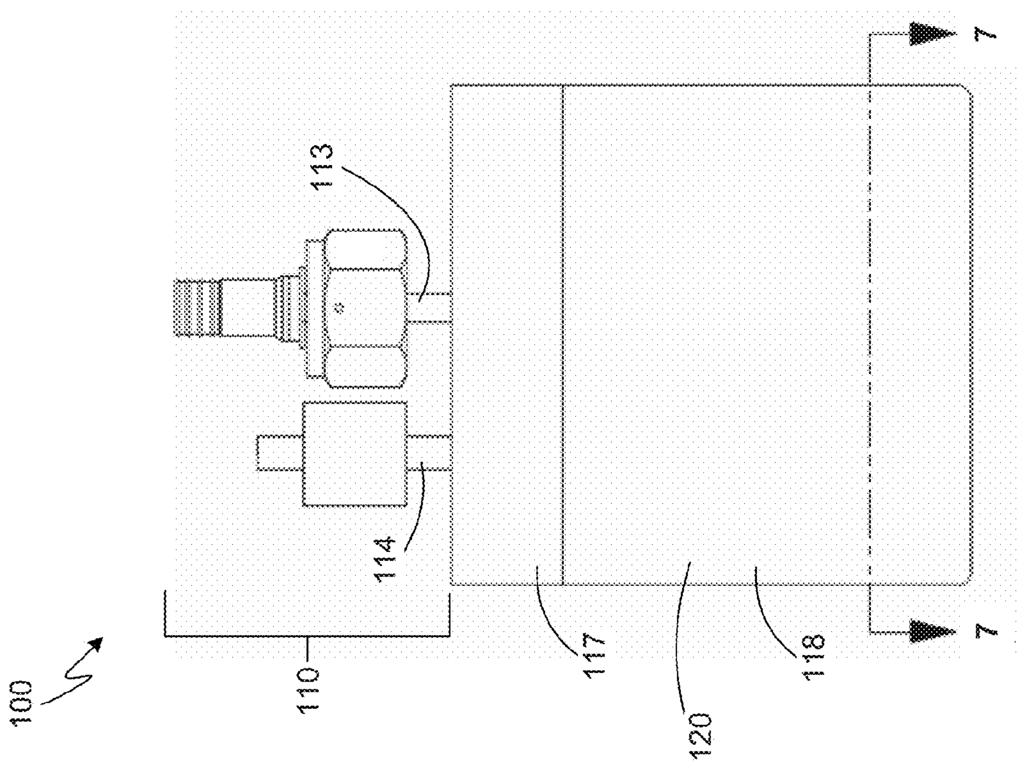


Figure 2

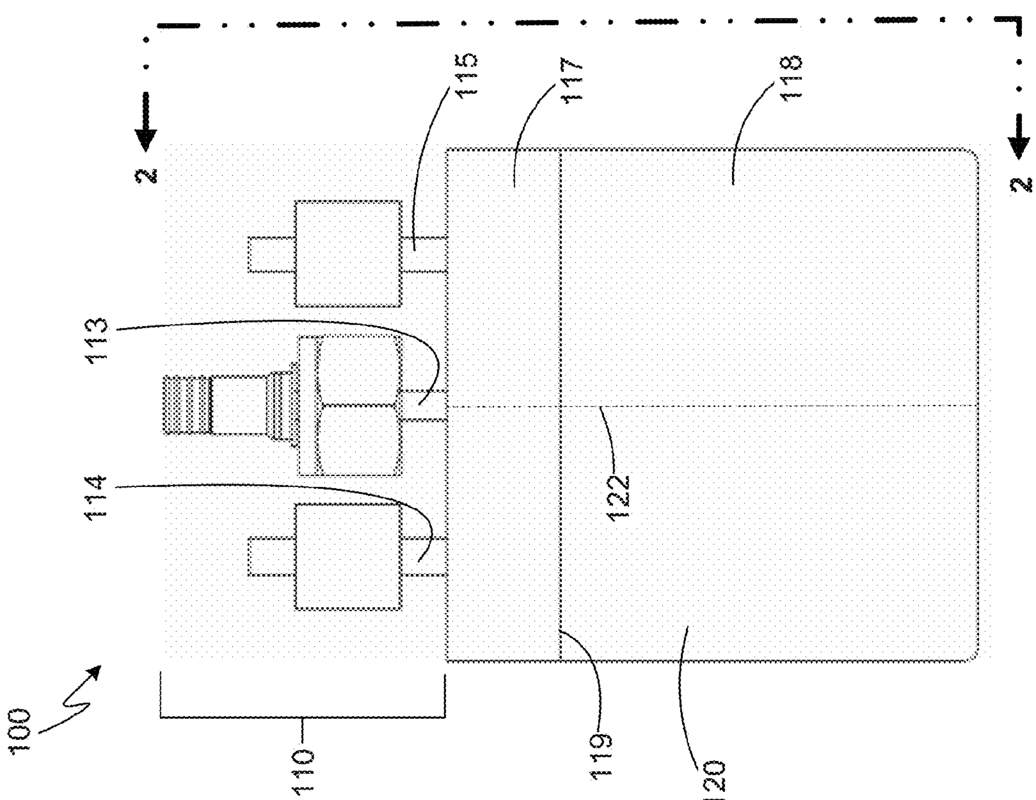


Figure 1

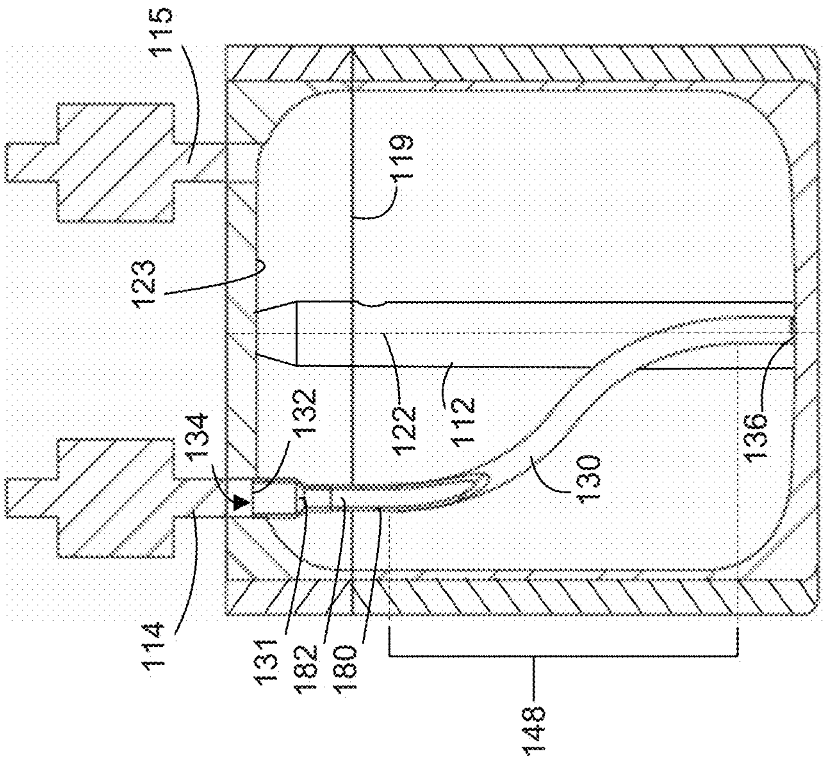


Figure 4

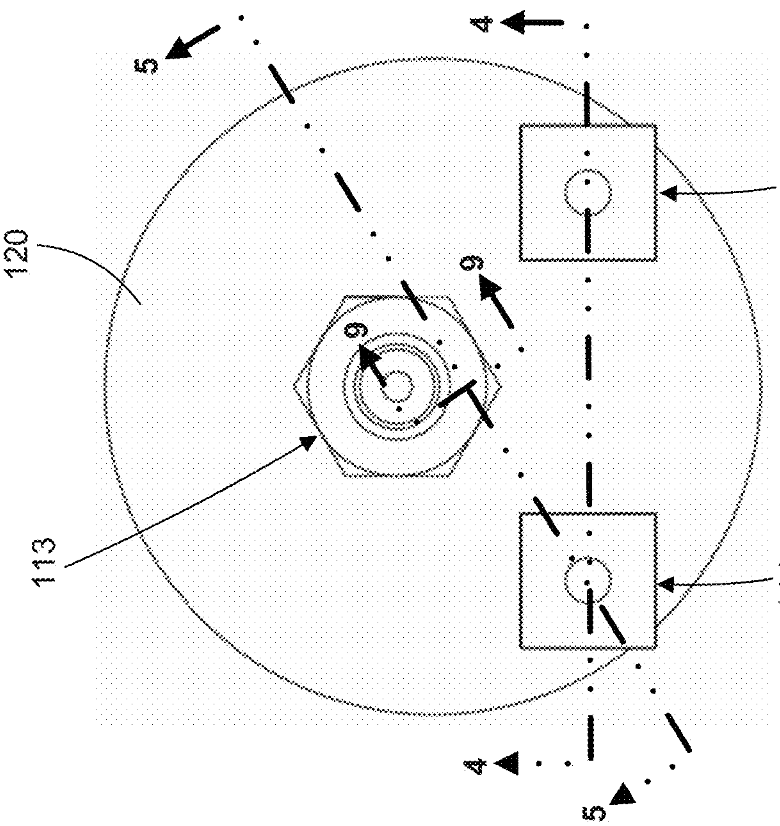


Figure 3

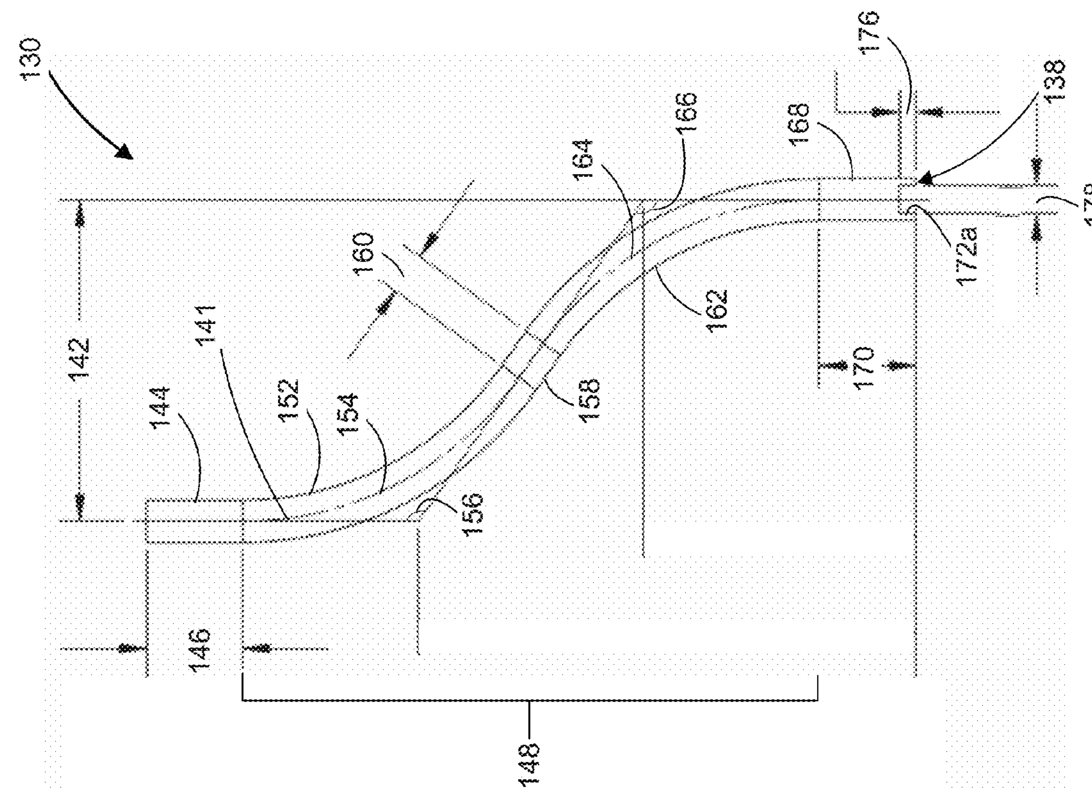


Figure 6

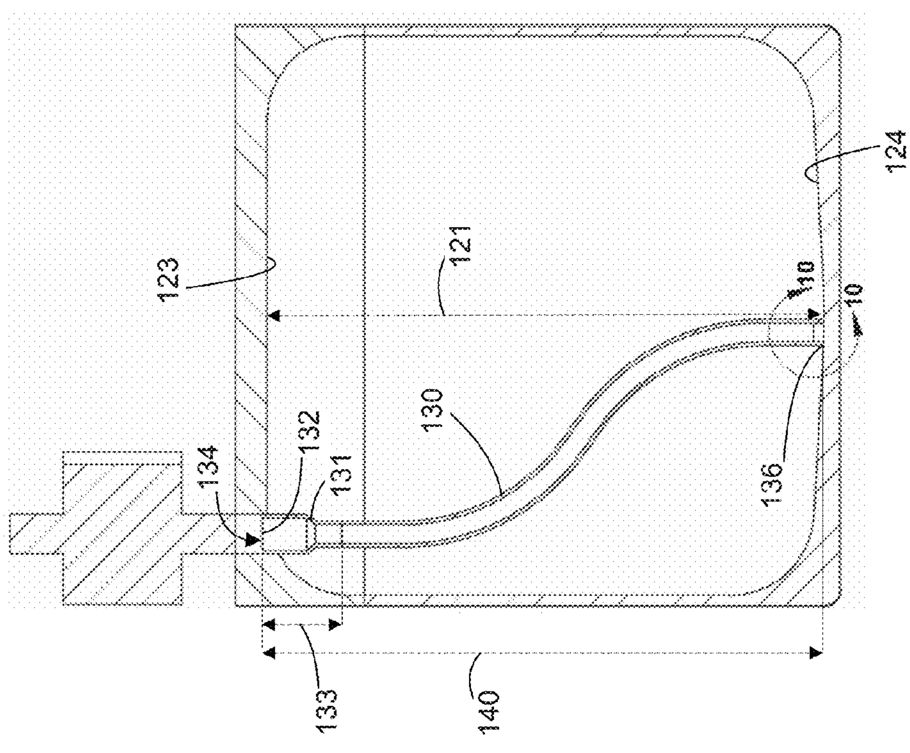


Figure 5

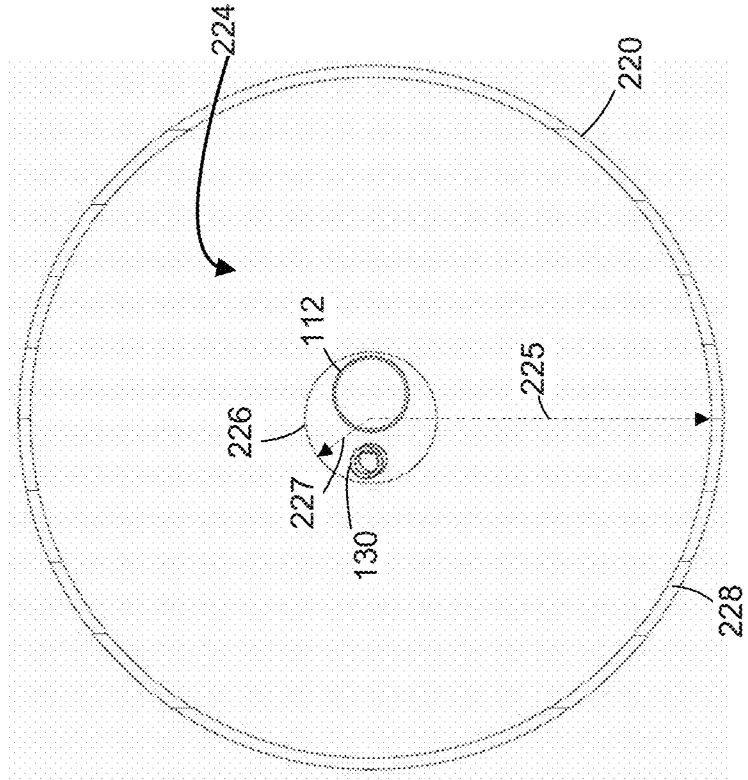


Figure 8

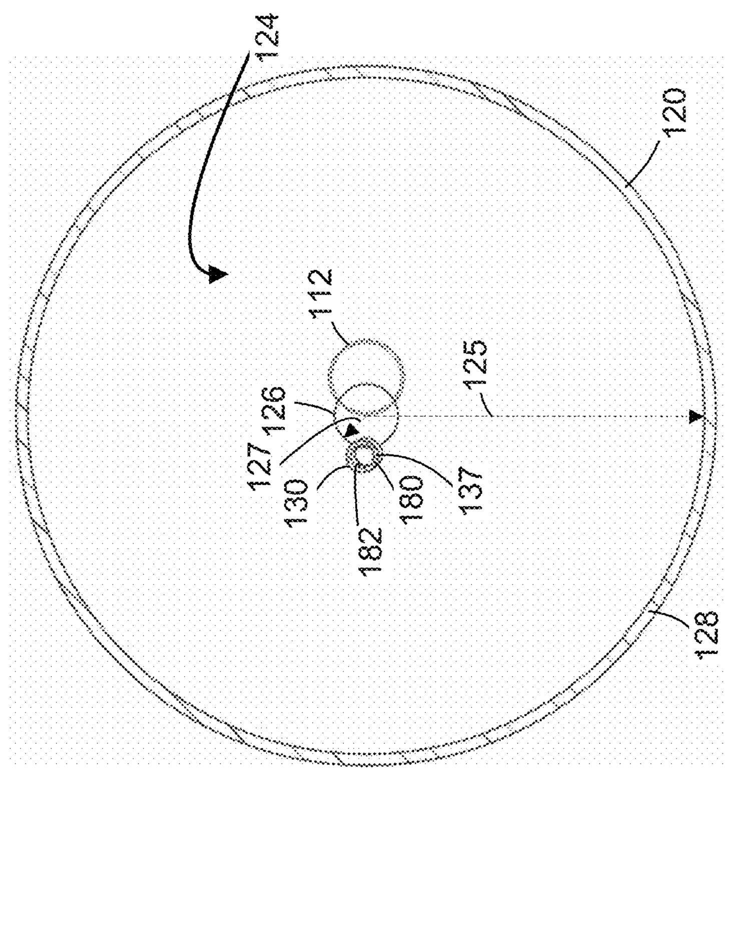


Figure 7

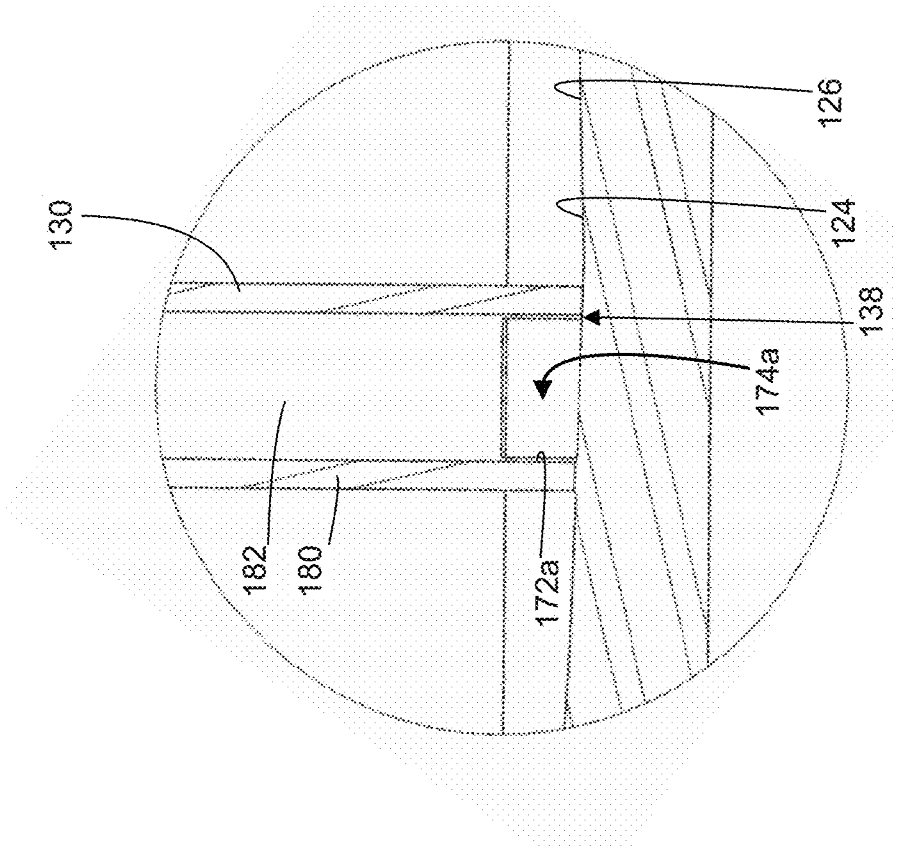


Figure 10

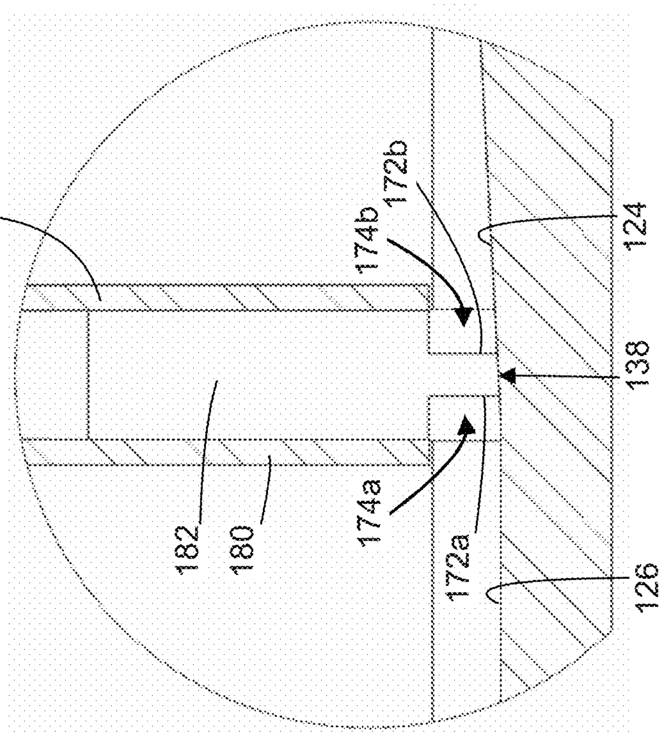


Figure 9

DIPTUBE DESIGN FOR A HOST AMPOULE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and benefit of U.S. Provisional Ser. No. 62/016,367, filed Jun. 24, 2014, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

The electronic device fabrication industry requires various liquid chemicals as raw materials or precursors to fabricate integrated circuits, wafers, and other electronic devices. The purity of the chemicals that are used in these applications must be very high in order to meet the stringent requirements of the electronic fabrication industry.

A portion of the efforts used to provide high purity chemicals goes into the design and structure of the containers and systems which deliver these chemicals to the reactor or furnaces where the electronic devices are being fabricated. The purity of the chemicals can deteriorate over time due to thermal decomposition, physical agitation, or chemical reaction with oxygen, moisture, or other contaminants located within the system. It is therefore desirable to periodically in-situ clean the chemical containers with cleaning agent or solvent and a purge gas. However, the solvent itself can serve as a contaminant during the fabrication process if not removed completely from the chemical container before processing chemicals are reintroduced. Therefore, it is desirable to evacuate as much of the solvent as possible from the chemical container after the cleaning process.

In addition, it is important to monitor the quantity of high purity chemical available in the container during its use in the electronic device fabrication process to ensure that enough chemical is available for batch processing and/or fabrication of the wafers. Because the high purity chemicals used in the fabrication process are very expensive, it is desirable to consume as much of the chemical as possible prior to conducting a cleaning cycle. However, it is also important to not empty the chemical container completely, because without leaving any residual chemical (i.e., heals) in the container, the electronic device fabrication process can operate in a run-dry condition, which can result in wafer defects and costly reductions in product yields. Therefore, careful monitoring of the quantity of remaining chemical in the chemical container is desirable.

Various attempts have been made in the prior art to address the issues of purity and monitoring of the quantity of chemicals available for use in chemical containers.

Some known prior art references disclose chemical containers comprising inlet and outlet valves and a diptube, but do not teach a level sensor probe or any means to measure the quantity of chemical remaining in the container.

Another known prior art reference discloses a chemical container with a diptube and an internal float level sensor.

Another known prior art reference discloses a chemical container with a rounded floor and a diptube.

Yet another known prior art reference discloses a chemical container with inlet and outlet valves, a diptube comprising a bend, and a chemical level sensor probe, but in this reference the base portion of the container has a rounded floor and the diptube does not make contact with the floor of the base portion.

There is a need to address the shortcomings of the prior art in addressing the goals of chemical purity, chemical quantity monitoring, and efficient chemical utilization.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

The present invention will hereinafter be described in conjunction with the appended drawing figures wherein like numerals denote like elements:

FIG. **1** is a front view of a host ampoule in accordance with a first embodiment of the present invention;

FIG. **2** is a right side view thereof shown along line **2-2** of FIG. **1**;

FIG. **3** is a top view thereof;

FIG. **4** is a sectional view taken along line **4-4** of FIG. **3**;

FIG. **5** is a sectional view taken along line **5-5** of FIG. **3**;

FIG. **6** is a side view of a diptube in accordance with an embodiment of the present invention;

FIG. **7** is a sectional view taken along line **7-7** of FIG. **2**;

FIG. **8** is a sectional view of a second embodiment of a host ampoule, taken along a line that is equivalent to line **7-7** of FIG. **2**;

FIG. **9** is a partial sectional view taken along line **9-9** of FIG. **3**, showing the bottom end of the diptube; and

FIG. **10** is a close-up view of the area designated by line **10-10** in FIG. **5**.

DETAILED DESCRIPTION OF THE INVENTION

The ensuing detailed description provides preferred exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of the invention. Rather, the ensuing detailed description of the preferred exemplary embodiments will provide those skilled in the art with an enabling description for implementing the preferred exemplary embodiments of the invention. Various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the invention, as set forth in the appended claims.

For purposes of the present specification and the appended claims, a "bend" is defined as a tubular member having at least one non-infinite radius of curvature. Preferably, the radius of curvature of the bend is less than 1000 cm.

For purposes of the present specification and the appended claims, two lines, surfaces, planes, parts, components, or assemblies are considered to be "substantially parallel" to another when an absolute value of the measurement of the angle between the two lines, surfaces, planes, parts, components, or assemblies does not exceed 10 degrees.

For purposes of the present specification and the appended claims, the term "flow communication" refers to the nature of connectivity between two or more parts or components that enables liquids, vapors, and/or gases to be transported between the parts or components in a controlled fashion (i.e., without leakage). Coupling together two or more parts or components such that they are in flow communication with each other can involve any suitable method known in the art, such as by the use of welds, flanged conduits, gaskets, fasteners, and adhesives. Two or more parts or components may also be coupled together in "flow communication" via intermediate components of the system that may physically separate them.

Generally, a host ampoule (container) for use in the electronic device fabrication industry is formed with a lower, base portion and an upper lid. A diptube is generally first fixedly attached to the underside of the lid, for example by welding. Then, the container is fully constructed by placing the lid and joined diptube atop the base portion and fixedly attaching the lid to the base portion, for example via a perimetral weld or via a plurality of bolts, clamps, or other fasteners. In welded applications, due to shrinkage that will inevitably occur in the weld, it is difficult to size a straight diptube properly such that it is long enough to reach the bottommost portions of the container after the weld shrinkage has occurred in an orientation that both maximizes its ability to drain and fill the container, as appropriate, and short enough that it does not fully seal itself against the interior bottom surface of the container such that it can no longer function.

Additionally, because in some applications it is desirable to have the bottom end of a diptube centrally located within the container, and owing to the fact that existing diptubes are straight, the diptube generally takes up a substantial portion of the central volume of the container (i.e., the volume located approximately along the centerline of the height of the container). This central volume of the container is therefore not free to receive other components of the system, for example a fluid level sensor probe.

In some embodiments according to the present invention, the "central volume" of the container comprises the cylindrically-shaped volume of the container that is measured along the height of the container centered about the centerline thereof, the central volume having a radius that is measured orthogonally from the centerline. In additional embodiments according to the present invention, the central volume of the container has a radius with a value that is at least 5% but no greater than 75% of the value of the radius of the container. In additional embodiments according to the present invention, the central volume of the container has a radius with a value that is at least 5% but no greater than 50% of the value of the radius of the container. In additional embodiments according to the present invention, the central volume of the container has a radius with a value that is approximately 5%-30% of the value of the radius of the container.

The present invention provides an improved diptube design for a host ampoule (container) that facilitates the refill, waste recovery, and cleaning processes of all wetted surfaces via a single line between the container and a connected refill/recovery system. The diptube is of full-length design and will reach the bottommost portions of the container, thereby allowing the entire contents of the container to be pushed out when the diptube is used as a drain in a first mode of operation of the system. The diptube can also be used to deliver cleaning solution to the bottommost portions of the container in the second mode of operation of the system. In this second mode of operation, a second line is connected at its first end to the headspace of the container (e.g., via port **115**) and at its second end to a waste recovery container. The cleaning agent or solvent can thus be pushed into the container via the diptube, thereby filling the container, and then the used cleaning agent or solvent solution can be pushed out through the second line into the connected waste recovery container. The diptube design according to the present invention reduces the required cleaning time and the quantity of solvent and purge gas needed during the cleaning process.

Like existing systems, the diptube according to the present invention is first fixedly attached, e.g., welded, to the lid of the container before the lid is fixedly attached—e.g., welded, clamped, or bolted—to the base portion. However,

unlike existing systems, the diptube of the present invention is shaped with a bend and the diptube is sized such that the lid and joined diptube need to be pressed down while atop the container bottom to fixedly attach the lid to the container bottom. The bend located in the diptube generates an inherent mechanical spring effect in the diptube when it is compressed that maintains the bottom edge of the diptube in perimetral contact with the interior bottom surface of the container, even in embodiments where weld shrinkage between the lid and base portion has caused the diptube to become further compressed within the container. The bend, furthermore, orients the bottom end of the diptube such that it remains perimetrally sealed with the interior bottom surface of the container, despite the weld shrinkage.

Further, in some embodiments according to the present invention, the bend in the diptube places the top end of the diptube such that it is welded to an off-center port which is not aligned along the centerline of the container. In these embodiments, this off-center placement of the diptube permits the central volume of the container to remain free in order to receive a level sensor probe for measuring the chemical level remaining in the container. In some embodiments according to the present invention, the container has a planar (flat) portion of the interior bottom surface of the container which represents the lowermost interior surface of the container, and to which both the diptube and level sensor probe extend. In some embodiments, the planar portion is located within the central volume of the container. In alternate embodiments, the planar portion could be located anywhere within the volume of the container, for example offset from a centerline of the container all the way out to an outer perimetral wall of the container. By permitting the level sensor probe to extend all the way down to this planar portion, the level sensor probe can provide the most accurate possible measurements of the chemical level remaining in the container.

The bottom end of the diptube is also provided with a pair of notches which oppose another along the perimeter of the bottom edge of the diptube. As noted above, the inherent mechanical spring effect in the diptube forces the bottom edge of the diptube against the interior bottom surface of the container. With the bottom edge perimetrally sealed to the interior bottom surface of the container via the spring constant generated by the diptube, the diptube notches act as drain holes that facilitate headspace pressure to be used in the container to force liquids and solid residue through the diptube and out of the container via the notches to fully drain and dry the container for continued use. While in the present embodiment exactly two notches are provided at the bottom end of the diptube, in alternate embodiments any number of notches could be provided at the bottom end of the diptube that extend through the exterior wall of the diptube into the interior passageway thereof. In further alternate embodiments, the notches could comprise one or more holes, slots or other perforations that are located near the bottom end of the diptube and that extend through the exterior wall of the diptube into the interior passageway thereof.

The combined features of the off-center diptube with inherent spring effect, the container with a concave interior bottom surface, and the level sensor probe located within the central volume of the container allows for the use of a single refill line to both recover chemical waste, cleaning agent or solvent, or purge gas from all wetted surfaces within the container and to dry and refill the container with fresh chemical for the production or fabrication process.

Referring generally to FIGS. **1**-**7**, **9**, and **10**, an exemplary embodiment of a system **100** in accordance with the present invention will now be described in detail. In this embodiment, the system **100** comprises a valve/line assembly **110** attached to a host ampoule or container **120**. The container has a base portion **118** and a lid **117** that is placed atop the base portion **118** and perimetrally welded thereto, leaving a visible weld **119**. As noted above, in alternate embodiments the lid **117** could be fixedly attached to the base portion **118** via other means, for example by a plurality of clamps or bolts located around the perimeters thereof. Referring back to the Figures, in this embodiment the lid **117** has a lower (interior) surface **123** (see FIGS. **4** and **5**). FIG. **1** is a front view of the system **100**, and FIG. **2** is a right side view thereof shown along line **2-2** of FIG. **1**. As shown in FIGS. **1**, **3**, and **4**, ports **114**, **115** enter the container **120** at a location away from a centerline **122** of the container **120**. Port **114** is welded or otherwise fixedly attached to a top edge **134** of a top end **132** of a diptube **130**, which includes a coupling **131** that acts to reduce the diameter of the piping of the port **114** to the diameter of the diptube **130**. In this embodiment, the diameter of the piping of the port **114** is 0.375 inches (0.953 centimeters), and the diameter of the diptube **130** is 0.250 inches (0.635 centimeters), thus requiring the coupling **131**. In alternate embodiments, the diameters of the piping of the port **114** and the diptube **130** may be equal, thus eliminating the need for the coupling **131**. In the present embodiment, the container **120** has an interior bottom surface **124** that is substantially concave and includes a planar portion **126** (see FIG. **7**) thereon located about the centerline **122** of the container **120**. The exterior walls of the container **120** are defined by an outer perimetral wall **128** (see FIG. **7**).

As shown in FIGS. **4** and **6**, in this embodiment the diptube **130** has a bend **148** in it that generates an inherent mechanical spring effect that allows a bottom edge **138**, which is located at a bottom end **136** of the diptube **130**, to effectively seal with the interior bottom surface **124**, and to remain sealed with the interior bottom surface **124** despite any weld shrinkage that may occur at the weld **119** between the lid **117** and the base portion **118** of the container **120**. Further, as shown in FIG. **5**, by having the diptube **130** connect at its top end **132** to the port **114** away from the central volume of the container **120** (i.e., away from the volume that is approximately along the centerline **122** of the container **120**), the central volume is free to receive a level sensor probe **112** that is used to measure the level of chemical (or other liquid) that is remaining in the container **120**. The level sensor probe **112** is attached to the lid **117** via a gland **113**. Because the level sensor probe **112** can therefore extend all the way down to the lowermost interior surface of the container **120** (i.e., to the planar portion **126** of the interior bottom surface **124**), the level sensor probe **112** can provide the most accurate possible measurements of the chemical level remaining in the container **120**.

The lowermost interior surface of the container **120** corresponds with the planar portion **126**, which in this embodiment is located along the centerline **122** of the container **120**. In alternate embodiments, the planar portion **126** could be located anywhere on the interior bottom surface **124** of the container, and need not be along the centerline **122** or within the central volume of the container **120**. In alternate embodiments, the planar portion **126** need not be circular and can be any shape with an area that comprises between 0.0001% and 100% of the area of the interior bottom surface **124**.

Details of an embodiment of the diptube **130** are shown in FIGS. **5** and **6** in its installed (i.e., compressed) state, with the coupling **131**—which has a length **133**—omitted from view in FIG. **6**. As shown in FIG. **5**, in this embodiment the diptube **130** has a height **140** that is measured from the top end of the coupling **131** to the bottom end of the tubular portion of the diptube **130**, and this height **140** is slightly greater than the maximum internal height **121** of the container **120**, which is measured between the lower surface **123** of the lid **117** and the planar portion **126** of the interior bottom surface **124**. The radial centerline of the top end **132** of the diptube **130** is offset from (i.e., is not collinear with) the radial centerline of the bottom end **136** of the diptube **130** by an offset distance **142**. In this embodiment, the top edge **134** is parallel with the bottom edge **138**.

In alternate embodiments according to the present invention, the top edge **134** is substantially parallel to the bottom edge **138**. In further alternate embodiments, the top edge **134** and bottom edge **138** need not be parallel or substantially parallel.

Moving from top end **132** to bottom end **136**, the diptube **130** has a top straight portion **144** having a length **146**, the bend **148**, and a bottom straight portion **168** having a length **170**. The bend **148** is comprised of a top curved portion **152** having a length **154**, a middle straight portion **158** having a length **160**, and a bottom curved portion **162** having a length **164**. It should be understood that the lengths **154**,**164** are measured along the curvature of the respective curved portions **152**,**162**. In this embodiment, the top straight portion **144** is parallel to the bottom straight portion **168**, the top straight portion **144** is angled with respect to the middle straight portion **158** by an angle **156**, and the bottom straight portion **168** is angled with respect to the middle straight portion **158** by an angle **166**. In this embodiment, the values of the angles **156**,**166** are both 135 degrees. Preferably, the values of the angles **156**,**166** are in the range of 91-179 degrees. More preferably, the values of the angles **156**,**166** are in the range of 100-170 degrees. Even more preferably, the values of the angles **156**,**166** are in the range of 120-150 degrees. Although in the present embodiment the values of the angles **156**,**166** are equal when the diptube **130** is installed and compressed within the container **120**, in alternate embodiments the values of the angles **156**,**166** need not be equal after installation. Where it is desirable to have the angles **156**,**166** be equal after installation, it may be necessary to make the initial value of angle **156** slightly greater than the initial value of angle **166**, because in this embodiment the top curved portion **152** is more likely to become compressed than the bottom curved portion **162**, thus affecting the value of angle **156** more than the value of angle **166**.

In this embodiment, the length **141** of the diptube **130** is measured along the curvature thereof, and is equal in value to the sum of the values of the length **133** of the coupling **131**, the length **146** of the top straight portion **144**, the length **154** of the top curved portion **152**, the length **160** of the middle straight portion **158**, the length **164** of the bottom curved portion **162**, and the length **170** of the bottom straight portion **168**. In this embodiment, the length **141** is greater than the height **140** of the diptube **130**. Preferably, the value of the length **141** is between 5-30% greater than the value of the height **140** of the diptube **130**. More preferably, the value of the length **141** is between 10-20% greater than the value of the height **140** of the diptube **130**.

As shown in FIGS. **4**, **7**, **9**, and **10**, the diptube **130** comprises an exterior wall **180** and an interior passageway **182** that connects the top end **132** in flow communication with the bottom end **136**. In this embodiment, the diptube **130** is tubular and therefore the cross-sectional area of the open portion (i.e., interior passageway **182**) of the diptube **130** is circular. In alternate embodiments, the interior passageway **182** of the diptube **130** may have a cross-sectional area that is square, rectangular, triangular, hexagonal, octagonal, or any other suitable regular or irregular geometric shape.

In this embodiment, the diptube **130** is shaped with the bend **148**, thus creating the inherent mechanical spring effect via a leaf spring design. In alternate embodiments according to the present invention, the diptube **130** may include more than one bend, or may have a coiled or helical shape with the turns of the spring oriented either horizontally or vertically, such that the spring constant in the diptube **130** is generated via a compression spring effect or torsional spring effect. In any embodiment according to the present invention, the diptube **130** should have a spring constant that is great enough such that when the diptube **130** is compressed within the container **120**, the bottom edge **138** of the diptube **130** creates and maintains a perimetral seal with the interior bottom surface **124** of the container **120**.

As seen in FIGS. **5**, **6**, **9**, and **10**, in this embodiment the bottom end **136** of the diptube **130** includes a pair of notches **172***a*,**172***b* which are arranged opposite another around the perimeter **137** of the bottom end **136** of the diptube **130**. Notch **172***a* forms an opening **174***a* that extends into the interior passageway **182** and notch **172***b* forms an opening **174***b* that extends into the interior passageway **182**. Each of the notches **172***a*,**172***b* has a height **176** and a two-dimensional linear width **178** (see FIG. **6**). In this embodiment, the openings **174***a*,**174***b* are rectangular when viewed orthogonally, although in alternate embodiments other shapes are possible for the openings **174***a*,**174***b*, including but not limited to semi-circular, square, triangular, or wedge-shaped. Although two notches **172***a*,**172***b* are included in the diptube **130** in the present embodiment, any number of notches could be used in alternate embodiments in keeping with the spirit of the present invention. In further alternate embodiments, the notches could be replaced with holes, slots, cutouts, or other perforations having any possible shape.

As discussed above, the inherent mechanical spring effect in the diptube **130** caused by compression of the diptube **130** and the bend **148** forces the bottom edge **138** of the diptube **130** against the interior bottom surface **124** of the container **120**, and effectively maintains a seal between the bottom edge **138** and the interior bottom surface **124**. With the bottom edge **138** perimetrally sealed to the interior bottom surface **124** of the container **120**, headspace pressure can be used in the container **120** (for example via port **115**) to force liquids and solid residue through the diptube **130** and out of the container **120** via the notches **172***a*,**172***b* to fully drain and dry the container **120** in preparation for chemical refilling.

As shown in FIG. **7**, in the present embodiment the planar portion **126** of the interior bottom surface **124** of the container **120** is aligned along the centerline **122** of the container **120**, and the bottom ends of the diptube **130** and level sensor probe **112** terminate such that they each partially terminate within the planar portion **126** (rather than come partially into contact with the planar portion **126**, the bottom end of the level sensor probe **112** may be located above and at least partially vertically aligned within a perimeter of the planar portion **126**). The interior bottom surface **124** has a radius **125** that is measured from the centerline **122** to the inner surface of the outer perimetral wall **128**, and the planar portion **126** has a radius **127** that is measured from the centerline **122** to the boundary of the planar portion **126**. In this embodiment, the value of the radius **127** of the planar portion **126** is approximately in the range of 5-15% of the value of the radius **125** of the interior bottom surface **124**. In an alternate embodiment of the container **220** as shown in FIG. **8**, the interior bottom surface **224** has a planar portion **226** of enlarged size such that the bottom ends of the diptube **130** and level sensor probe **112** each fully terminate within the planar portion **226** (rather than come into contact with the planar portion **226**, the bottom end of the level sensor probe **112** may be located above and completely vertically aligned within a perimeter of the planar portion **226**). The interior bottom surface **224** has a radius **225** that is measured from the centerline of the container **220** to the inner surface of the outer perimetral wall **228** thereof, and the planar portion **226** has a radius **227** that is measured from the centerline of the container **220** to the boundary of the planar portion **226**. In the embodiment of FIG. **8**, the value of the radius **227** of the planar portion **226** is approximately in the range of 15-25% of the value of the radius **225** of the interior bottom surface **224**. In further alternate embodiments, the radius **227** of the planar portion **226** could be equal in value to the radius **225** of the interior bottom surface **224** of the container; in other words, the entire interior bottom surface **224** could comprise the planar portion **226**. In still further alternate embodiments, the planar portion **226** may comprise any possible percentage of the area of the interior bottom surface **224** of the container. In alternate embodiments, the planar portion **126** need not be circular and can be any shape with an area that comprises between 0.0001% and 100% of the area defined by **124**.

In the herein described embodiment, the perimetral width of the openings **174***a*,**174***b* collectively comprise between 25-50% of the value of the perimeter **137** of the bottom end **136** of the diptube **130** (i.e., the openings **174***a*,**174***b* collectively extend between 90 and 180 degrees around the perimeter **137** of the bottom end **136**). In alternate embodiments, the perimetral width of the openings **174***a*,**174***b* may collectively comprise less than 25% or greater than 50% of the value of the perimeter **137** of the bottom end **136** of the diptube **130**, for example between 0.1-99.9% of the value of the perimeter **137**.

While the principles of the invention have been described above in connection with preferred embodiments, it is to be clearly understood that this description is made only by way of example and not as a limitation of the scope of the invention.

FURTHER ASPECTS OF THE INVENTION

Further aspects of the invention include:

Aspect 1: A container for containing and dispensing a liquid chemical, the container comprising a lid having a lower interior surface and a plurality of ports extending through the lid, a base portion having an interior bottom surface; and a diptube, the diptube comprising an exterior wall defining an interior passageway, a top end that is fixedly attached to a first port of the plurality of ports and extends from the lower interior surface, and a bottom end having a bottom edge, at least a portion of the bottom edge being in contact with the interior bottom surface of the base portion when the lid is affixed to the base, the bottom end further comprising at least one notch that extends to the bottom edge and through the exterior wall into the interior passageway.

Aspect 2: The container according to Aspect 1, the diptube further comprising at least one bend located between the top end and bottom end thereof, wherein the at least one bend generates a spring force that retains the bottom edge at least partially in contact with the interior bottom surface of the base portion.

Aspect 3: The container according to either of Aspect 1 or Aspect 2, wherein a centerline of the top end of the diptube is not collinear with a centerline of the bottom end of the diptube.

Aspect 4: The container according to Aspect 3, wherein the centerline of the top end is substantially parallel with the centerline of the bottom end.

Aspect 5: The container according to any of Aspects 1-4, wherein the entire bottom edge is in contact with the interior bottom surface of the container.

Aspect 6: The container according to any of Aspects 1-5, the bottom end of the diptube further comprising at least one hole that extends through the exterior wall into the interior passageway but does not come into contact with the bottom edge.

Aspect 7: The container according to any of Aspects 1-6, wherein the top end of the diptube has a top edge, and the top edge is substantially parallel with the bottom edge.

Aspect 8: The container according to any of Aspects 1-7, wherein the interior bottom surface of the container has a planar portion, and at least a portion of the bottom edge of the diptube contacts the planar portion.

Aspect 9: The container according to Aspect 8, wherein the planar portion comprises the lowermost portion of the interior bottom surface.

Aspect 10: The container according to Aspect 8, further comprising a level sensor having a top end and a bottom end, the top end being attached to a second port of the plurality of ports, wherein the bottom end is located above and at least partially vertically aligned within a perimeter of the planar portion.

Aspect 11: The container according to any of Aspects 1-10, the diptube further comprising an uncompressed height that is measured between a top edge of the top end and the bottom edge thereof when the diptube is in an uncompressed state and a compressed height that is measured between the top edge and a lowermost portion of the interior bottom surface of the container that is in contact with the bottom edge when the diptube is installed in the container, wherein the uncompressed height is greater than the compressed height.

Aspect 12: A method comprising: (a) fixedly attaching a top end of a diptube to a lid, the diptube comprising a bottom end having a bottom edge, the diptube comprising an exterior wall defining an interior passageway, the lid further comprising a plurality of ports extending therethrough; (b) locating the lid above a base portion having an interior bottom surface such that at least a portion of the bottom edge of the bottom end of the diptube comes into contact with the interior bottom surface; (c) applying force to the lid or the base portion until the lid and base portion are mated together and the diptube is at least partially compressed within the base portion; and (d) fixedly attaching the lid to the base portion while performing step (c).

Aspect 13: The method according to Aspect 12, wherein step (a) further comprises fixedly attaching the top end of the diptube to the lid, wherein the bottom end of the diptube comprises at least one notch that extends to the bottom edge and through the exterior wall into the interior passageway.

Aspect 14: The method according to either of Aspect 12 or Aspect 13, wherein step (a) further comprises fixedly attaching the top end of the diptube to the lid, the diptube having a bend located between the top end and bottom end thereof such that a centerline of the top end is not collinear with a centerline of the bottom end.

Aspect 15: The method according to any of Aspects 12-14, wherein step (a) further comprises fixedly attaching the top end of the diptube to a lower surface of the lid at a location that is not located within a central volume of the container after the lid has been fixedly attached to the base portion in step (d), the central volume being located along a height of the container between the lower surface of the lid and the interior bottom surface, the height being measured along a centerline of the container between a centerpoint of the lower surface of the lid and a centerpoint of the interior bottom surface, the base portion having a radius that is measured orthogonally from the centerline to an interior surface of an outer wall of the container, the central volume having a radius that is measured orthogonally from the centerline, the radius of the central volume having a value that is no greater than 75% of the value of the radius of the base portion.

Aspect 16: A container for containing and dispensing a liquid chemical, the container comprising: a lid having a lower surface and a plurality of ports extending therethrough, a base portion having an interior bottom surface and an outer wall having an interior surface, a height measured along a centerline of the base portion between a centerpoint of the lower surface of the lid and a centerpoint of the interior bottom surface, the base portion having a radius that is measured orthogonally from the centerline to the interior surface of the outer wall, and a central volume that is located along the height between the lower surface of the lid and the interior bottom surface, the central volume having a radius that is measured orthogonally from the centerline, the radius of the central volume having a value that is no greater than 75% of the value of the radius of the base portion; and a diptube, the diptube comprising a top end that is fixedly attached to the lid, the top end being located entirely external to the central volume, and a bottom end that is located at least partially within the central volume, the bottom end having a bottom edge, wherein at least a portion of the bottom edge is in contact with the interior bottom surface.

Aspect 17: The container according to Aspect 16, the bottom end of the diptube further comprising at least one notch that extends to the bottom edge of the diptube and through an exterior wall of the diptube into an interior passageway thereof.

Aspect 18: The container according to either of Aspect 16 or Aspect 17, the diptube further comprising an integral bend located therein between the top end and the bottom end.

Aspect 19: The container according to any of Aspects 16-18, wherein the radius of the central volume has a value that is at least 5% of the value of the radius of the base portion.

Aspect 20: The container according to any of Aspects 16-19, wherein the entire bottom edge is in contact with the interior bottom surface.

The invention claimed is:

1. A container for containing and dispensing a liquid chemical, the container comprising:

a lid having a lower interior surface and a plurality of ports extending through the lid,

a base portion having an interior bottom surface; and

a diptube, the diptube comprising:

an exterior wall defining an interior passageway,

a top end that is fixedly attached to a first port of the plurality of ports and extends from the lower interior surface, and

a bottom end having a bottom edge, at least a portion of the bottom edge being in contact with the interior bottom surface of the base portion when the lid is affixed to the base portion, the bottom end further comprising at least one notch that extends to the bottom edge and through the exterior wall into the interior passageway wherein the diptube further comprises an uncompressed height that is measured between a top edge of the top end and the bottom edge thereof when the diptube is in an uncompressed state and a compressed height that is measured between the top edge and a lowermost portion of the interior bottom surface of the container that is in contact with the bottom edge when the diptube is installed in the container, wherein the uncompressed height is greater than the compressed height.

2. The container of claim **1**, the diptube further comprising at least one bend located between the top end and bottom end thereof, wherein the at least one bend generates a spring force that retains the bottom edge at least partially in contact with the interior bottom surface of the base portion.

3. The container of claim **1**, wherein a centerline of the top end of the diptube is not collinear with a centerline of the bottom end of the diptube.

4. The container of claim **3**, wherein the centerline of the top end is substantially parallel with the centerline of the bottom end.

5. The container of claim **1**, wherein the entire bottom edge is in contact with the interior bottom surface of the container.

6. The container of claim **1**, the bottom end of the diptube further comprising at least one hole that extends through the exterior wall into the interior passageway but does not come into contact with the bottom edge.

7. The container of claim **1**, wherein the top end of the diptube has a top edge, and the top edge is substantially parallel with the bottom edge.

8. The container of claim **1**, wherein the interior bottom surface of the container has a planar portion, and at least a portion of the bottom edge of the diptube contacts the planar portion.

9. The container of claim **8**, wherein the planar portion comprises the lowermost portion of the interior bottom surface.

10. The container of claim **8**, further comprising a level sensor having a top end and a bottom end, the top end being attached to a second port of the plurality of ports, wherein the bottom end is located above and at least partially vertically aligned within a perimeter of the planar portion.

11. A method comprising:

(a) fixedly attaching a top end of a diptube to a lid, the diptube comprising a bottom end having a bottom edge, the diptube comprising an exterior wall defining an interior passageway, the lid further comprising a plurality of ports extending therethrough;

(b) locating the lid above a base portion having an interior bottom surface such that at least a portion of the bottom edge of the bottom end of the diptube comes into contact with the interior bottom surface;

(c) applying force to the lid or the base portion until the lid and base portion are mated together and the diptube is at least partially compressed within the base portion; and

(d) fixedly attaching the lid to the base portion while performing step (c).

12. The method of claim **11**, wherein step (a) further comprises fixedly attaching the top end of the diptube to the lid, wherein the bottom end of the diptube comprises at least one notch that extends to the bottom edge and through the exterior wall into the interior passageway.

13. The method of claim **11**, wherein step (a) further comprises fixedly attaching the top end of the diptube to the lid, the diptube having a bend located between the top end and bottom end thereof such that a centerline of the top end is not collinear with a centerline of the bottom end.

14. The method of claim **11**, wherein step (a) further comprises fixedly attaching the top end of the diptube to a lower surface of the lid at a location that is not located within a central volume of the container after the lid has been fixedly attached to the base portion in step (d), the central volume being located along a height of the container between the lower surface of the lid and the interior bottom surface, the height being measured along a centerline of the container between a centerpoint of the lower surface of the lid and a centerpoint of the interior bottom surface, the base portion having a radius that is measured orthogonally from the centerline to an interior surface of an outer wall of the container, the central volume having a radius that is measured orthogonally from the centerline, the radius of the central volume having a value that is no greater than 75% of the value of the radius of the base portion.

15. A container for containing and dispensing a liquid chemical, the container comprising:

a lid having a lower surface and a plurality of ports extending therethrough,

a base portion having an interior bottom surface and an outer wall having an interior surface,

a height measured along a centerline of the base portion between a centerpoint of the lower surface of the lid and a centerpoint of the interior bottom surface, the base portion having a radius that is measured orthogonally from the centerline to the interior surface of the outer wall, and

a central volume that is located along the height between the lower surface of the lid and the interior bottom surface, the central volume having a radius that is measured orthogonally from the centerline, the radius of the central volume having a value that is no greater than 75% of the value of the radius of the base portion; and

a diptube, the diptube comprising

a top end that is fixedly attached to the lid, the top end being located entirely external to the central volume, and

a bottom end that is located at least partially within the central volume, the bottom end having a bottom edge, wherein at least a portion of the bottom edge is in contact with the interior bottom surface.

16. The container of claim **15**, the bottom end of the diptube further comprising at least one notch that extends to the bottom edge of the diptube and through an exterior wall of the diptube into an interior passageway thereof.

17. The container of claim **15**, the diptube further comprising an integral bend located therein between the top end and the bottom end.

18. The container of claim **15**, wherein the radius of the central volume has a value that is at least 5% of the value of the radius of the base portion.

19. The container of claim **15**, wherein the entire bottom edge is in contact with the interior bottom surface.

* * * * *